WHAT IS CLAIMED:

SUB B2

1. A product comprising a plurality of substantially aligned carbon nanotubes attached to a substrate at a density greater than 10^4 nanotubes per square millimeter of substrate.

2. A product as claimed in claim 1, wherein the carbon nanotubes extend outwardly from and substantially perpendicular to the substrate.

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3. A product as claimed in claim 1, wherein the carbon nanotubes extend outwardly from and at a non-perpendicular angle with respect to the substrate.

4. A product as claimed in claim 1, wherein the carbon nanotubes extend substantially parallel to the substrate.

5. A product as claimed in claim 1, wherein the nanotubes have a diameter between 4 to 500 nanometers.

6. A product as claimed in claim 1, wherein the nanotubes have a diameter of at least 50 nanometers.

7. A product as claimed in claim 1, wherein the substrate has a strain point or melting point temperature up to 3000°C.

8. A product as claimed in claim 1, wherein the substrate has a strain point or melting point temperature of at least about 300°C.

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9. A product as claimed in claim 1, wherein the substrate comprises glass, silica, quartz, silicon, iron, cobalt, nickel, an alloy of iron, cobalt, or nickel, platinum, a ceramic, or a combination thereof.

10. A product as claimed in claim 9, wherein the substrate is a glass plate.

11. A product as claimed in claim 9, wherein the substrate is a silicon wafer.

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12. A product as claimed in claim 1, wherein substantially all carbon nanotubes have a cap distal from the substrate comprising a metal or a metal alloy.

Sub B3 cont'd

13. A product as claimed in claim 12, wherein the cap is iron, cobalt, nickel, or an alloy of iron, cobalt, or nickel.

14. A product as claimed in claim 13, wherein the cap is nickel.

15. A product as claimed in claim 1, further comprising a filling within the carbon nanotubes.

16. A product as claimed in claim 1, wherein substantially all carbon nanotubes have an open end.

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17. A product as claimed in claim 16, further comprising a filling within the carbon nanotubes.

18. A product as claimed in claim 17, wherein the filling is hydrogen, lithium ions, bismuth, lead telluride, or bismuth tritelluride.

19. A product as claimed in claim 17, wherein the filling is a pharmacological agent.

20. A product as claimed in claim 17, wherein the filling is enclosed within the carbon nanotubes.

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21. A product comprising a plurality of substantially aligned carbon nanotubes attached to a substrate at a density no greater than 10^2 nanotubes per square millimeter of substrate.

22. A product as claimed in claim 21, wherein the carbon nanotubes extend outwardly from and substantially perpendicular to the substrate.

23. A product as claimed in claim 21, wherein the carbon nanotubes extend outwardly from and at a non-perpendicular angle with respect to the substrate.

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24. A product as claimed in claim 21, wherein the carbon nanotubes extend substantially parallel to the substrate.

25. A product as claimed in claim 21, wherein the nanotubes have a diameter between 4 to 500 nanometers.

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26. A product as claimed in claim 21, wherein the nanotubes have a diameter of at least about 50 nanometers.

27. A product as claimed in claim 21, wherein the substrate has a strain point or melting point temperature up to 3000°C.

28. A product as claimed in claim 21, wherein the substrate has a strain point or melting point temperature of at least about 300°C.

29. A product as claimed in claim 21, wherein the substrate comprises glass, silica, quartz, silicon, iron, cobalt, nickel, an alloy of iron, cobalt, or nickel, platinum, a ceramic, or a combination thereof.

30. A product as claimed in claim 29, wherein the substrate is a glass plate.

31. A product as claimed in claim 29, wherein the substrate is a silicon wafer.

32. A product as claimed in claim 21, further comprising a filling within the carbon nanotubes.

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33. A product as claimed in claim 21, wherein substantially all carbon nanotubes have an open end.

34. A product as claimed in claim 33, further comprising a filling within the carbon nanotubes.

35. A product as claimed in claim 34, wherein the filling is hydrogen, lithium ions, bismuth, lead telluride, bismuth tritelluride, or a pharmacological agent.

36. A product as claimed in claim 34, wherein the filling is enclosed within the carbon nanotubes.

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37. A product comprising a substrate having a strain point or a melting point temperature between about 300°C and 700°C and one or more carbon nanotubes.

38. A product comprising a substrate having an outer surface and a plurality of substantially aligned carbon nanotubes originating and extending outwardly from the outer surface.

39. A product comprising a substrate having an outer surface and one or more free-standing carbon nanotubes originating and extending from the outer surface.

40. A method of forming a product with one or more carbon nanotubes on a substrate comprising:

providing a substrate in a reduced pressure environment containing a carbon source gas and a catalyst gas and

exposing the substrate to a plasma under conditions effective to cause formation and growth of one or more carbon nanotubes on the substrate.

41. A method according to claim 40, wherein the reduced pressure environment has a pressure between about 0.1 to about 100 Torr.

42. A method according to claim 41, wherein the reduced pressure environment has a pressure between about 1 to about 20 Torr.

43. A method according to claim 40, wherein the product has a strain point or melting point temperature between 300°C and 3000°C.

44. A method according to claim 40, wherein the substrate comprises glass, silica, quartz, mesoporous ~~silicon~~, silicon, iron, cobalt, nickel, an alloy of iron, cobalt, or nickel, platinum, a ceramic, or a combination thereof.

45. A method according to claim 44, wherein the substrate is a glass plate.

46. A method according to claim 44, wherein the substrate is a silicon wafer.

47. A method according to claim 40, wherein the carbon source gas is a saturated or unsaturated linear, branched, or cyclic carbon and hydrogen compound having up to six carbon atoms.

48. A method according to claim 47, wherein the carbon source gas is acetylene, ethylene, or benzene.

49. A method according to claim 40, wherein the catalyst gas is ammonia or nitrogen.

50. A method according to claim 40, wherein the volume ratio of carbon source gas to catalyst gas ranges from about 1:2 to about 1:10.

51. A method according to claim 40, wherein the substrate is exposed to the plasma at a temperature below 700°C.

52. A method according to claim 40, wherein the substrate is exposed to the plasma at a temperature above about 300°C.

53. A method according to claim 40, wherein the substrate is exposed to the plasma at a temperature between 300°C and 3000°C.

54. A method according to claim 40, further comprising:

disposing a catalyst film onto the substrate by radio frequency magnetron sputtering prior to said providing the substrate in a reduced pressure environment containing a carbon source gas and a catalyst gas.

55. A method according to claim 40, wherein the substrate has a catalyst film disposed thereon.

56. A method according to claim 55, wherein the film has a thickness of at least about 15 nanometers.

57. A method according to claim 55, wherein the film is nickel, iron, cobalt, or an alloy of nickel, iron, or cobalt.

58. A method according to claim 57, wherein the film is nickel.

59. A method according to claim 55, further comprising:

varying the carbon nanotube diameter in direct proportion to the film thickness.

60. A method according to claim 40, further comprising:

disposing a catalyst nano-dot onto the substrate by electron beam evaporation, thermal evaporation, or magnetron sputtering prior to said providing the substrate in a reduced pressure environment containing a carbon source gas and a catalyst gas.

61. A method according to claim 60, wherein each nano-dot forms one carbon nanotube.

62. A method according to claim 40, wherein the substrate has at least one catalyst nano-dot disposed thereon.

63. A method according to claim 62, wherein each nano-dot forms one carbon nanotube.

64. A method according to claim 62, wherein the at least one nano-dot is nickel, iron, cobalt, or an alloy of nickel, iron, or cobalt.

65. A method according to claim 64, wherein the at least one nano-dot comprises nickel.

66. A method according to claim 40, further comprising:

varying the carbon nanotube diameter in inverse proportion to the plasma intensity.

67. A method according to claim 40, further comprising:

varying the carbon nanotube length in direct proportion to the plasma intensity.

68. A method according to claim 40, wherein the one or more carbon nanotubes have a cap, and further comprising:

removing the cap from the one or more carbon nanotubes to form open-end on the one or more carbon nanotubes.

69. A method according to claim 68, wherein the cap is removed by HNO_3 solution etching.

70. A method according to claim 68, wherein the cap is removed by argon ion sputtering.

71. A method according to claim 68, further comprising:

adding a filling into the one or more carbon nanotubes after said removing the cap.

72. A method according to claim 71, further comprising:

enclosing the open-ends of the one or more carbon nanotubes after said adding a filling to store the filling within the one or more carbon nanotubes.

73. A method according to claim 72, wherein the open-ends of the one or more carbon nanotubes are enclosed by electrochemical deposition or magnetron sputtering of a metal onto the one or more carbon nanotubes.

74. A method according to claim 40, wherein the one or more carbon nanotubes have a closed end and further comprising:

exposing the one or more carbon nanotubes to oxygen under conditions effective to remove the closed end.

75. A method according to claim 74, further comprising:

adding a filling into the one or more carbon nanotubes.

76. A method according to claim 74, further comprising:

enclosing the one or more carbon nanotubes after said adding a filling to store the filling within the one or more carbon nanotubes.

77. A method according to claim 76, wherein the one or more carbon nanotubes are enclosed by electrochemical deposition or magnetron sputtering of a metal onto the one or more carbon nanotubes.

78. A field emission display comprising:

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a baseplate having an electron emitting array positioned thereon and

a phosphor coated plate spaced apart from the baseplate so that electrons emitted from the array impinge on the phosphor coating, wherein the baseplate comprises a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of

substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate.

79. An electron emitter comprising:

an electron generating source and

a product having at least one carbon nanotube operably connected to the electron generating source to emit electrons from the at least one carbon nanotube, wherein the product comprises a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of substrate; (3) one or more carbon nanotubes, wherein the product has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate.

80. A scanning electron microscope comprising:

a vacuum chamber capable of receiving a specimen;

an electron source for producing electrons;

a probe for emitting and directing the electrons toward and scanning the specimen operably disposed within the vacuum chamber;

a detector operably positioned within the vacuum chamber for collecting radiation issuing from the specimen as a result of scanning by the probe to produce an output signal; and

a display screen operably connected to the detector to display an image of the area of the specimen scanned by the probe, wherein the probe comprises a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a

substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate.

81. A battery comprising:

an anode;

a cathode;

an insulator disposed between the anode and the cathode; and

an electrolyte,

wherein at least one of the anode and the cathode comprise a product having a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate.

82. A fuel cell comprising:

a housing;

a gas diffusion anode positioned within the housing to form an anode side;

a gas diffusion cathode positioned within the housing to form a cathode side;

an electrolyte impregnated matrix or ion exchange membrane positioned between and in electrical contact with the anode and the cathode;

an external circuit electrically and operably connecting the anode to the cathode; and

an enclosed hydrogen storage unit operably connected to the anode side comprising a product having a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater

than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate, wherein substantially all carbon nanotubes have at least one diffusion path; and

hydrogen gas disposed within the carbon nanotubes.

83. A composite comprising:

a product comprising a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate and

a dissimilar material in admixture with the product, wherein the dissimilar material is selected from the group consisting of metal, ceramic, glass, polymer, graphite, and mixtures thereof.

84. A high temperature superconductor comprising:

65 a product having a substantially non-electrically conductive substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate,

a high-temperature copper oxide superconductor material in admixture with the product, and

at least two spaced apart terminals electrically connected to the admixture of the product and the high-temperature copper oxide superconductor material and engagable with an electric circuit.

85. An electromagnetic interference (EMI) shield comprising:

a product comprising a substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate and

a dissimilar material in admixture with the product, wherein the dissimilar material is a polymer, graphite, or a combination thereof, wherein said electromagnetic interference shield is operationally positioned with respect to either an electromagnetic source or an electronic component.

86. A microelectrode comprising:

a product comprising a substantially non-electrically conductive substrate and either (1) a plurality of substantially aligned carbon nanotubes of a density greater than 10^4 nanotubes per square millimeter of substrate; (2) a plurality of substantially aligned carbon nanotubes of a density no greater than 10^2 nanotubes per square millimeter of a substrate; (3) one or more carbon nanotubes, wherein the substrate has a strain point or melting point temperature between about 300°C and 700°C; (4) a plurality of substantially aligned carbon nanotubes originating and extending outwardly from an outer surface of the substrate; or (5) one or more free-standing carbon nanotubes originating and extending outwardly from an outer surface of the substrate and

at least one electrically conductive microfiber operably connected to at least one carbon nanotube of the product, wherein the at least one carbon nanotube is operably and electrically connectable to an electric circuit.